A Price Differential for Whole Milk

Based on Fat Test and Feed Cost of Production

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Approximately half the milk produced in Illinois is sold by the producer as whole milk, and about the same ratio holds for the entire United States. Most of this milk is purchased in bulk by milk distributors and by them in turn sold at retail to city consumers. In earlier years it was customary to pay the same price per hundredweight of milk regardless of the fat content of the milk. This custom has gradually changed until at the present time it is a common practice to make a difference in the price paid for the milk according to its fat test.[1]

Setting Price by the Fat Test

A common system of expressing the price paid for whole milk is to name a certain price per hundredweight for milk testing a certain fat percentage. This price may be called the *base price* and the fat test to which it applies, the *base fat percentage*. For milk testing higher than the base fat percentage, the price is increased by adding to the base price a certain amount for each "point" above the base fat percentage. For lower testing milk, a corresponding decrease is made in the price. A "point" is .1 on the fat percentage scale. The allowance in price per hundredweight per point may be called the *price differential for fat test*.

For example, suppose the base price is $2.00 for 3.5-percent milk, and the price differential 3 cents. The producer delivering milk testing 3.5 percent fat receives $2.00 a hundredweight for his milk. If he delivers milk testing 3.3 percent fat he receives $1.94 a hundredweight; if he delivers 4.0-percent milk, the price is $2.15 a hundredweight, and so forth. The three specifications—*base price, base fat percentage,* and *price differential*—serve to determine the price for milk of any fat percentage.

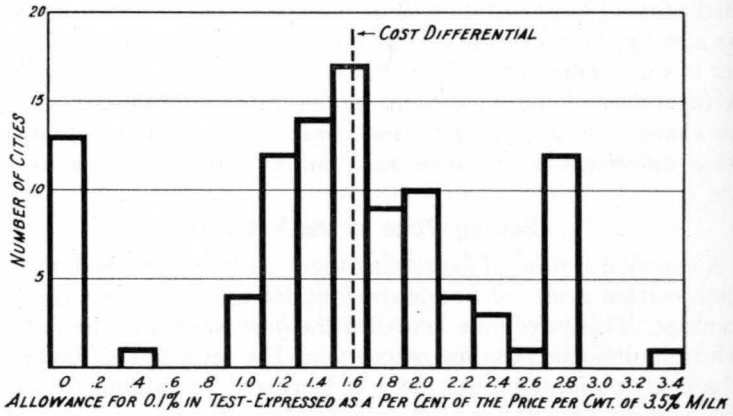
Price Differentials in 101 City Markets

The price differential naturally varies with the general level of prices. Therefore if we wish to compare the price differential in vari-

[1]A difference in price based on sanitary quality, as measured by bacterial count or otherwise, is sometimes made by city markets. The sanitary and chemical qualities together give a good measure of the worth of the milk. This circular, however, is concerned only with the chemical quality as measured by fat test.

ous city markets, we must take account of the base price. The accompanying graph shows the distribution of 101 cities in the United States with respect to the price differential which they have allowed, the differential being expressed as a percentage of the price per hundredweight for 3.5-percent milk. This makes a fair comparison to show the variability in the practice of different cities.

The tall column at the extreme left of the graph shows that at the time the information was collected there were 13 cities out of the 101



PRICE DIFFERENTIALS FOR 101 CITIES IN THE UNITED STATES
(Data derived from Fluid Milk Market Report,
U. S. Department of Agriculture, August, 1923)

which made no price difference. That is to say, these 13 cities paid the same price for milk regardless of the fat test. Near the right of the graph there is another tall column representing 12 cities which made a price differential equal to 2.8 percent (i.e., between 2.7 and 2.899 percent) of the price of 3.5-percent milk. Most of these cities paid in exact proportion to the fat test, which is equivalent to a price differential of 2.857 percent of the price of 3.5-percent milk ($100 \times \frac{.1}{3.5} = 2.857$).

The rest of the cities, with one exception, fall in between these two extremes. The most common price differential is at 1.6 percent (i.e. between 1.5 and 1.699 percent) of the price of 3.5-percent milk. There were 17 cities out of the 101 in this class. The other groupings taper off on either side of this class in a fairly regular manner between the two extremes at 0 and 2.8. There seem to be, therefore, three types of markets: one making no allowance at all for fat test; another basing payment entirely on the fat test, and the third taking an intermediate but variable position.

The Feed Cost Differential[1]

Just as we have spoken of the price differential, we may speak of the *feed cost differential,* that is, the difference per hundredweight per point in the feed cost of producing milk. The cost of producing milk is affected by a large number of factors. One important factor is that of the quality of the milk with respect to fat percentage.

It has been found that the relative feed cost of producing milk, so far as it is affected by the percentage of fat in the milk, is proportional to the *percentage of fat plus 2.66.* The feed cost differential is accordingly 1.623 percent of the feed cost of 3.5-percent milk $\left(100 \times \frac{.1}{3.5 + 2.66} = 1.623\right)$. How this compares with the price differential may be seen by referring again to the graph, on which the relative feed cost differential is indicated by the broken vertical line. The various city markets seem to group themselves around this line representing the feed cost of production.

Is the Market Favorable to Low or High Testing Milk

It is probable that the *total* cost of milk production, so far as it is affected by the fat percentage of the milk, is proportional to the feed cost of production. Assuming that this is so, then the same relations that have been found to hold for feed cost hold also for the total cost.[2]

Both the milk producer and distributor are interested in the cost differential, for if the relative price differential is more than the relative cost differential, the market is favorable to the production of high-testing milk, and if the relative price differential is lower than the relative cost differential, the market is favorable to the production of low-testing milk. When the market goes to the extreme of making no allowance for fat percentage, as in the 13 cities at the left of the graph, it is decidedly favorable to the production of low-testing milk. When the market goes to the other extreme of paying exactly in proportion to the fat test, as in the 12 cities at the right in the graph, it is decidedly favorable to the production of high-testing milk. If the price differential is proportional to the cost differential, the market is equally favorable to milk of any test.

In order to know whether any given price differential is proportional to the feed cost differential, one needs to know the base price

[1]The basis for the feed cost relations has been published in Bulletins 244 and 245 of this Station, and in the Journal of Agricultural Research of December 15, 1924, pages 593-601. Copies of these publications will be supplied on request.

[2]The assumption is merely this: If under a given set of conditions feed cost is 60 percent of the total cost of producing 3.5-percent milk, it will be 60 percent of the total cost of producing 4.0-percent milk, or milk of any other test. If under another set of conditions feed cost is 45 percent of the total cost of 3.5-percent milk, it will be 45 percent also of 4.0-percent milk, or milk of any other test.

and the base fat percentage. Table 1 has been prepared to show the price differential which is proportional to the feed cost differential with different combinations of these two items, base price and base fat percentage. Thus, if the base price is $2.10 a hundredweight and the base fat percentage is 3.0, the corresponding differential is 3.71

TABLE 1.—PRICE DIFFERENTIAL WHICH IS PROPORTIONAL TO FEED COST DIFFERENTIAL

Base price per hundredweight	Base fat percentage		
	3.0	3.5	4.0
	Price differential per hundredweight which is proportional to feed cost		
	cts.	*cts.*	*cts.*
$1.00	1.77	1.62	1.50
1.10	1.94	1.79	1.65
1.20	2.12	1.95	1.80
1.30	2.30	2.11	1.95
1.40	2.47	2.27	2.10
1.50	2.65	2.44	2.25
1.60	2.83	2.60	2.40
1.70	3.00	2.76	2.55
1.80	3.18	2.92	2.70
1.90	3.36	3.08	2.85
2.00	3.53	3.25	3.00
2.10	3.71	3.41	3.15
2.20	3.89	3.57	3.30
2.30	4.06	3.73	3.45
2.40	4.24	3.90	3.60
2.50	4.42	4.06	3.75
2.60	4.59	4.22	3.90
2.70	4.77	4.38	4.05
2.80	4.95	4.55	4.20
2.90	5.12	4.71	4.35
3.00	5.30	4.87	4.50
3.10	5.48	5.03	4.65
3.20	5.65	5.19	4.80
3.30	5.83	5.36	4.95
3.40	6.01	5.52	5.10
3.50	6.18	5.68	5.25
3.60	6.36	5.84	5.40
3.70	6.54	6.01	5.55
3.80	6.71	6.17	5.70
3.90	6.89	6.33	5.85

cents. If the price differential is less than 3.71 cents, it is in favor of low-testing milk; if more than 3.71 cents, it is favorable to high-testing milk. In the same way if the base price is $3.10 a hundredweight and the base fat percentage is 4.0, the corresponding differential is 4.65 cents; and so on for the other combinations.

Danish Experiments Support Feed Cost Formula[1]

Some rather extensive experiments carried out in Denmark confirm the general soundness of the principle of estimating relative feed costs as proportional to the *percentage of fat plus 2.66*. The experiments referred to were conducted under the supervision of the Danish Experiment Station and had as their object the determination of the amount and economy of production of Red Danish and Jersey cows and of crosses between these two breeds. Records were kept of the feed consumed, milk produced, fat test of the milk, and various other items. The cows were kept on a large private estate and the management was entirely on a commercial basis for economical production. A summary of ten years' results is given in Table 2.

TABLE 2.—DATA FROM DANISH EXPERIMENTS BEARING ON FEED CONSUMPTION IN RELATION TO FAT TEST OF THE MILK

(Ten Years—1909-1919)

	Red Danish	Crossbred	Jersey
Number of cows	368	350	353
Average age of cows, yrs. and mos.	5–7	5–10	5–9
Average weight per cow	1,021 lbs.	913 lbs.	796 lbs.
Average milk per cow per year	7,934 lbs.	6,389 lbs.	5,018 lbs.
Average fat test of milk	3.60%	4.28%	5.34%
Feed units per cow per year	3,079	2,748	2,484
Feed units[1] per cwt. of milk	38.8	43.0	49.5
Relative feed cost by formula[2]	38.8	43.0	49.6

[1]Danish feed unit = 1 kilogram (2.2 pounds) of barley or its equivalent.
[2]Feed cost proportional to *percentage of fat plus 2.66*.

It will be noted that we are dealing in Table 2 with three different groups of cows according to breeding. The number of cows involved, 350 or more in each group, should make the average results very reliable. The average age of the cows in the different groups is about the same. In the other items listed, the groups differ greatly, that is in weight, milk yield, fat test of the milk, feed consumed per cow per year, and feed consumed per hundredweight of milk yielded.

The last two lines of Table 2 show that the feed units consumed per hundredweight of milk produced are proportional to the *percentage of fat plus 2.66*. In other words, the feed cost of producing milk by

[1]The data of the Danish experiments are taken from "2. Meddelelse fra Forsøgslaboratoriets Husdyrbrugsafdeling," Royal Veterinary and Agricultural College, Copenhagen.

these three diverse groups of cows is in agreement with the formula *percentage of fat plus 2.66,* developed at the Illinois Station.

Formula Is Based on Physiological Principles

Our common feeding standards for milk production may be summed up by saying that the *nutrients* required to produce a pound of milk are proportional to the percentage of fat in the milk plus 2.66. In so far as the annual *milk yield* of cows is affected by its richness in fat, the yield is proportional to the percentage of fat plus 2.66. It is these two physiological relationships which provide the basis for the feed cost formula.

Incidentally it may be noted that the energy value of a given quantity of milk is approximately proportional to the percentage of fat plus 2.66. Hence, the food value of milk, measuring food value by energy content, is proportional to the feed energy required by the cow to produce the milk. From this standpoint, there is no inherent advantage in producing milk of any certain fat percentage, so far as the economy of conversion of cow feed into human food is concerned.

Adjusting Price According to Fat Test and Feed Cost

In adjusting the price of milk according to the fat test of the milk, the price would seem to be equally favorable to the production of low-testing and high-testing milk when it is proportional to the *percentage of fat plus 2.66.*